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Critical Literature Review
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Human impacts on breeding success of Antarctic penguins: A review

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Abstract:

The changing climate and its potential future impacts on the ecosystems of the planet, highlights the need to better understand factors which can leave a species vulnerable to change. In Antarctica, the wildlife is specially adapted to extreme environments, but many species are restricted to a limited latitudinal range, hence making them particularly vulnerable to a change in climate. At the same time, there is rapid growth in tourism, and continued growth in other activities in Antarctica. As wildlife is likely to come into contact with humans more and more, it is important to obtain as much information as possible on the potential effects of this interaction. The breeding success of a species is critical for a healthy population and therefore anything affecting breeding needs to be fully understood. Penguins are an iconic and abundant Antarctic species and this paper investigates what is known about human impact on their breeding success. The papers reviewed have very differing results so there is still uncertainty about the significance and magnitude of human impacts on breeding penguins. What has become clear however, is a need for more species specific studies, and also further understanding of other factors that may affect breeding success.

Introduction

Antarctica and the sub-Antarctic islands are becoming increasingly popular as tourist destinations. The number of tourists landing on Antarctica has risen from 7,413 in 1996-1997 to 25,284 in 2012-2013 (IAATO 2013). According to Pfeiffer & Peter (2004) this upward trend is expected to continue due to an increased number of ships, the use of larger vessels, and a wide variety of activities on offer. The number of scientists and other personnel living and working in the region is also increasing. The time when there is the most human activity in Antarctica, be it tourism or research activities, corresponds with the most vulnerable time for Antarctic wildlife. With this in mind it is important to investigate potential impacts human activities may have on the wildlife.

Penguins are an iconic Antarctic animal and very popular amongst tourists. There are 18 species of penguin in the world, 8 of which are found in the Antarctic or sub-Antarctic (Ancel et al. 2013). Although considered a marine animal, penguins remain dependent on the land for breeding, rearing young and moulting (Ancel et al. 2013). Their time of breeding is when they are at their most vulnerable. Eggs and chicks need to be closely guarded to protect them from exposure to the weather and to predators. Most Antarctic penguin species breed on ice-free areas along the coasts. The ice-free areas are the same places where tourists land ashore and where bases are built, thus allowing the interaction of penguins and humans.

The world's climate is undergoing change and although penguins are adapted to extreme environments, each species is restricted to a limited latitudinal range (Ancel et al. 2013). Therefore they can be highly sensitive to climate change and this may, in the future, be detrimental to their survival. For this reason it is vital to ensure penguin populations are in the best possible position to combat the potential future threat of climate change, and this means understanding those factors that can have a negative impact on the breeding cycle.

There appears to be a lack of consensus as to the specific impacts of human disturbance on breeding Antarctic penguins and this has consequences for decision-making regarding the management of human behaviour around colonies. This review looks at

what is known about these impacts. Although it focuses on the impacts of tourist visitation, it also briefly includes studies looking at the impacts of scientific activities. Several studies from other regions such as New Zealand and South America are also examined, as the results are interesting and may be prove useful when compared to other species and when looking at the management of Antarctic penguins.

Potential impacts

Tourists visiting penguin colonies in Antarctica generally walk past the colony on marked-out paths, observing but not physically interacting with the penguin in any way. Those tour companies operating under the International Association of Antarctic Tour Operators (IAATO) have strict regulations with regards to behaviour around penguin colonies. They recommend visitors approach penguins no closer than 5m, or further away if the penguin shows signs of agitation (IAATO 2013). Scientists on the other hand, may be required to physically interact with the birds. For example they may need to temporarily remove the bird from the colony in order to take measurements or blood samples. Although scientist numbers are less than the number of tourists, their activities on land are generally more intensive and widespread so it is important to also take into account the potential impacts they may cause.

There are many ways in which a penguin may respond to human disturbance and hence many different ways this can affect their breeding success. Responses include increased heart rate, increased vigilance and visible agitation, threat displays, abandonment of nests and other general disruptions to their everyday activities. There can also be physiological affects which may not be evident externally (Walker et al. 2006).

Looking first at the early stages of breeding, human disturbance may have an impact on a penguin's choice of nest site. A penguin may be dissuaded from choosing or establishing a nest in proximity to human activity. This appears to be especially relevant for young pre-breeders (Carlini et al. 2007, Trathan et al. 2008). These young birds may therefore be delayed in setting up a nest site and hence finding a mate, or it is suggested in some cases that juvenile birds may instead re-locate to other, less disturbed, colonies (Trathan et al. 2008).

In incubating birds, increased heart rate and vigilance are common responses to human presence. Although often considered minor or transitory (Holmes et al. 2005), these responses may be a precursor to a fight-or-flight response, and therefore may lead to a bird abandoning their nest. Groscolas et al. (2008) and Spee et al. (2011) agree that stress can cause a parent bird to abandon its eggs or chicks. If a parent bird moves away from its nest, this can leave the egg or chick vulnerable to environmental factors such as inclement weather or attack by predators. It may also cause territorial displacement which could lead to the destruction of eggs and young (McClung et al. 2004). Even if the parent does not move away from the nest altogether, it may stand up when disturbed, exposing the egg or chick to rapid cooling. If this occurs often enough, it could decrease the chance of survival of the egg or chick.

Human presence may also have an impact on the feeding of chicks. The presence of people on beaches may delay post-foraging landing by penguins provisioning their young (Ancel et al. 2013). This may affect the amount of food the chick is receiving and hence may have an effect on their overall health and survival. Salihoglu et al. (2001) confirms that the timing of food delivery is important and that interruptions to feeding can affect fledging weight. Studies have indicated that the probability of chick survival has a positive correlation with the chick's mass at fledging (Salihoglu et al. 2001).

Long term effects should also be taken into account. Walker et al. (2006) found that significant physiological changes could be occurring inside an animal without any external signs of stress. The study suggests that factors such as breeding success may not immediately appear to be affected by human disturbance, but that chronic stress can cause physiological effects which can have long term consequences and the potential to affect individuals in the future.

Although quite a few studies have looked at the direct effects of human disturbance on penguins, there has been very little work done on the indirect effects. Indirect impacts can include pollution and the introduction of diseases. Barbosa et al. (2013) looked at the potential indirect effects of human impacts observed in gentoo penguins at two sites, one heavily visited by tourists and one rarely visited. The penguins at the heavily visited

site showed a higher presence of heavy metals in their bodies, such as lead and nickel, and a higher number of erythrocytic nuclear abnormalities than did the penguins at the less visited site. Although there was no evidence of this necessarily effecting breeding success, it may ultimately impact upon the individual penguin's health, and thereby potentially affect their breeding performance.

Results of reviewed studies

The papers reviewed showed varying results. In some cases (Giese 1995, McClung et al. 2004, Ellenberg et al. 2006, Ellenberg et al. 2007, Holmes 2007, Lynch et al. 2010) there was clear evidence that human disturbance was impacting negatively on the breeding success of the birds. However other cases (Cobley & Shears 1999, Holmes et al. 2006, Carlini et al. 2007) showed no clear evidence of this. There were also several studies which showed higher breeding productivity at sites with a higher rate of visitation (Carlini et al. 2007, Lynch et al. 2010).

Significant negative impacts on breeding success that were attributed to human disturbance was found by Lynch et al. (2010) with gentoo penguins on the Antarctic Peninsula, Ellenberg et al. (2006) with Humboldt penguins in Chile and McClung et al. (2004) and Ellenberg et al. (2007) with Yellow-eyed penguins in New Zealand. Some studies found declines in breeding success but these were not considered to be caused by human disturbance. An example of this is Naveen et al's (2012) study on chinstrap penguins on Deception Island. Conversely, both Carlini et al. (2007) and Lynch et al. (2010) found higher reproductive success at highly visited sites compared to less visited sites. These studies were both on Adelie penguins on the Antarctic Peninsula.

A study worth mentioning is one by Giese (1995) who, unlike the majority of papers on the subject, compares different sources when looking at the impacts of human disturbance on Adelie penguin breeding success. The study differentiates between the potential impacts of tourists as opposed to researches. It compares tourist visitation with nest checking for scientific purposes. These in turn were compared to a control colony that had minimal disturbance. It was found that hatching success and chick

survival were lowest at the colonies subjected to recreational visits. It was second lowest at the nest checking sites, and highest at the control sites.

Another study worth mentioning, due to its interesting result, is that of Holmes et al. (2006). It looked at the possible habituation of birds exposed to regular human visitation. They studied two colonies of gentoo penguins on Macquarie Island. One colony was within the grounds of the research station and hence subject to high levels of human activity. The other colony was 'off-station', with comparatively low exposure to humans. It was found that the penguins off-station showed significantly stronger responses than those on-station, with a reduction in time spent resting and increased vigilance and threat display behaviour during and after pedestrian visitation. Holmes et al. (2006) suggests this may be due to the on-station penguins becoming accustomed to human presence and no longer seeing it as a threat.

Looking at overall population growth rates of penguin colonies, Naveen et al. (2012) found that over a 25 year period, populations of chinstrap penguins on Deception Island had shown a significant decrease. This was true for sites throughout the region including sites that received little or no tourism. Conversely, Cobley & Shears (1999) found that long term population trends of gentoo penguins at many sites on the Antarctic Peninsula indicate colonies have been growing. This is despite high and increasing levels of tourism. In many cases there is little understanding about why some populations of penguins are increasing and why some are decreasing.

Factors responsible for lack of consensus

Trathan et al. (2008) concluded that the lack of consensus in the above results is likely due to a number of different factors including the variety of different species studied, the different sites used and the varying types and intensity of human activities to which the penguins were exposed. The size of the colonies studied and the duration of the study can also influence results and should be taken into account.

Different studies focussing on different species of penguins can lead to conflicting results due to the individual nature of particular species. For example, some species of

penguin appear to be more sensitive to human disturbance than others. A study undertaken by Ellenberg et al. (2006) in Chile found Humboldt penguins responded more strongly to human presence than any other penguin species. Significant heart rate responses were noted in incubating birds even when a person was passing at a distance of 150m and hence breeding success at frequently visited sites was greatly reduced (Ellenberg et al. 2006). In comparison, Magellanic penguins show no reduced breeding success despite frequent tourist visitation of nests at close proximity (Ellenberg et al. 2006). Similarly, Holmes (2007) found gentoo penguins to be particularly sensitive to human presence when compared to king and Royal penguins, and a study by Lynch et al. (2010) found a significant decrease in breeding productivity of gentoo penguins at highly visited sites, but found a higher breeding productivity of Adelie penguins at the highly visited site. Human impacts on penguin breeding success therefore, appear to be species specific and this should be taken into account with tourism management.

Responses from the birds are also likely to be different depending on the size of the colony (Giese 1995, Holmes et al. 2005). For example Giese (1995) found human impact on breeding success to be significant in smaller colonies, whereas they were not significant in larger colonies with the same treatment applied. Cobley & Shears (1999) also suggest that in a particularly successful breeding season, penguins are more able to adapt to the stresses which can result from human disturbance.

A study by Holmes et al. (2006) mentions habituation and the possibility that birds may become accustomed to human presence and therefore show less response to visitation than those birds unaccustomed to human presence. This suggests that between colonies with similar visitation rates, bird responses can differ depending on the duration over which the colony has been exposed to human presence. Although, according to Walker et al. (2006) habituation can occur quite quickly. His study on Megallanic penguins in Argentina showed a rapid habituation to human visitation, with differences noted after only five days.

Long term studies are necessary as penguin populations tend to show inter-annual variability (Carlini et al. 2007, Ninnes et al. 2011). Trathan et al. (2008) found this inter-annual variability in both the number of breeding pairs and the breeding productivity

and concluded that there were many different factors influencing penguin breeding numbers. Several studies have referred to the impacts of environmental factors and how these, and not human disturbance, may be the cause of decreased breeding success in many cases. Indeed both Cobley & Shears (1999) and Carlini et al. (2007) suggest that changes in environmental variables have more impact than tourism. As an example Cobley & Shears (1999) and Trathan et al. (2008) found that late snow in localised areas can negatively impact upon the breeding success of gentoo penguins, and seasonal differences in the extent of sea ice has been found to affect the timing of breeding in Adelie penguins (Ninnes et al. 2011).

As was suggested by Holmes et al. (2005), the cumulative impacts of visitation are not well known but should be considered. Although some response shown by birds to human visitation may be classed as minor or transitory, if exposed to this over a long time it may lead to high levels of stress, which could have serious consequences for breeding productivity.

As shown at yellow-eyed penguin colonies on the Otago Peninsula, New Zealand, there can be significant impacts on breeding success when visitation is not regulated (Ellenberg et al. 2007, McClung et al. 2004). Most of the people visiting penguin sites in Antarctica are required to follow regulations and guidelines regarding their behaviour when visiting penguin colonies. Although studies have shown that there is evidence of negative impacts, these impacts do not appear to be as extreme as those examples in New Zealand where there are no regulations in place. This confirms the need for regulations and perhaps suggests stricter regulations are appropriate at particular sites.

Discussion:

Giese (1995) states that 'management agencies remain constrained by a lack of specific and scientifically rigorous information'. The conflicting results discussed in this paper are likely due to inconsistencies in the species studied, the study location, the duration and type of human disturbance and the different timescales over which the studies are performed. Due to the conflicting results found by the

various studies, the impact of human disturbance on the breeding success of Antarctic penguins remains unclear. This should not however, lead to complacency with regards to the regulation and management of human interaction with penguins. Instead, a precautionary approach should be taken. To use the adage "it's better to be safe than sorry", stricter regulations at particular sites are perhaps necessary to help mitigate potential and unknown future impacts. Regulations and guidelines for people coming into contact with penguins should be species specific and also site specific, to more accurately reflect the needs for that particular species in that particular area. The studies described in this paper show that using general guidelines for all species is inappropriate and potentially ineffective. Further studies are required on this subject so more certainty is achieved and informed decisions can be made for the conservation of Antarctic penguins.

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